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16. Abstract <p>The objective of this project is to describe freeze-up and break-up patterns of the seasonal snow and ice covers in Alaska. During the reporting period we have concentrated our efforts on 1) identifying analysing and describing snow and ice characteristics based on NASA provided positive prints and transparencies, 2) testing various technical means to provide further information from the ERTS data, 3) relating the observed build-up of snow and ice covers to meteorological data. Our analysis suggests that the ERTS data can provide information on the regional variations of the snow and ice covers which may be used to enhance the existing snow and ice survey programs of Alaska.</p>			
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I INTRODUCTION

This report summarizes work performed and conclusions reached during the first six months of Contract No. NAS 5-21833, ERTS-1 Project No. 110-4; "Survey of the seasonal snow cover of Alaska".

During the first six months we have received and catalogued MSS black and white 9 1/2 inch prints, 70 mm positive transparencies and 70 mm negatives for 165 scenes along the north-south transect across Alaska. Among these scenes, representing the snow build up period from early fall till the beginning of November, we have selected for analysis about 40 scenes with especially interesting snow and ice features. Most of these scenes have been or will be utilized for displays on the color additive viewer, for preparing enlarged and/or contrast enhanced prints, color-coded overlays, photomosaics etc. We have finished the first-look analysis of the air photos obtained during the NASA 92F-NP3A flights over Alaska in mid-July, 1972. We have analysed weather patterns and climatic records for Alaska during the snow build-up period and we are now in the process of relating the observed snow and ice covers to these data.

II STATUS OF PROJECT

A. Objectives.

The overall objective of our project is to determine the freeze-up and break-up patterns of the seasonal snow and ice covers, and to describe these patterns in terms of the main synoptic-climatological and hydrological regimes in Alaska. Specifically, we are interested in studying how the ERTS data can be used to enhance the existing snow survey programs in Alaska. We are also trying to find analytical means to identify various snow and ice characteristics, and to relate observed snow and ice patterns to physiographic features and to meteorological

parameters.

B. Accomplishments during the reporting period.

1. Supporting data analysis.

Climatological data. Synoptic surface weather maps and 500 mb Isohypse maps, climatological records including snow data, have been analysed and are being related to ERTS-1 data for the period Sept. 1 - Nov. 5, 1972. The analysis indicate that three synoptic situations had a decisive influence on the character of the freeze-up season. The first of these situations occurred around September 14-17, when cold air advection with a northerly to north-westerly flow at the 500 mb level took place over Bering Sea and western Alaska. In connection with the formation of a cold low over the Interior the flow became NNW-W over the southern half of Alaska. Within this cold air flow an occluded front moving mainly eastward across Alaska caused snow falls as reported by stations in the upper valleys of the Copper River and Cook Inlet Basins, Bristol Basin, West Central and Interior Basins. Also Barrow and Barter Island on the Arctic Slope in the north reported snow during this period. Practically all of this new snow was gone in the valleys after a few days.

A similar synoptic pattern developed during the period September 25-30 with mainly northwesterly flow at the 500 mb level over Chukotsk Peninsula and Bering Sea and westerly to southwesterly flow over Central Alaska. During this period two cold fronts moving approximately NW - SE caused significant snow falls over most of Alaska except for low-altitude stations in the south-east, south and south-west. Once again this snow at lower elevations except on the Arctic Slope disappeared in connection with a prolonged spell of unseasonably warm weather over Alaska in the middle of October.

The warm weather was associated with a quasi-stationary extensive low (at the 500 mb level) with its center in the vicinity of the western most Aleutian Islands. A trough outlier extending southwards towards latitudes 25-30° N caused advection of warm and moist air over Alaska from south to southwest. A new snow cover started to build up in the Interior towards the end of October under variable weather conditions.

Air photos. The NASA flights over Alaska in mid-July 1972, in support of University of Alaska ERTS programs, were made at a time when most of the seasonal snow and ice was already gone. Traces of the snow and ice covers were left on the Arctic Slope, in the Brooks Range, and in the high mountain areas in central and southern Alaska. The mountain snow cover had generally broken up into patches and a regional snow line could in general not be defined. Since the ERTS satellite did not view the flight line areas until some time after the flights, we cannot directly compare aircraft and satellite pictures as to seasonal snow and ice features. In our analysis of the ERTS scenes we have found that the identification and delineation of snow becomes problematic when the ground surface is covered by dense vegetation. We intend to use the air photos to characterize the snow-free surface as to vegetation, roughness, albedo etc, and then to use this information to check our interpretation of the ERTS data. We also intend to use the air photos for a synopsis of the snow and ice conditions across Alaska in the middle of the summer of 1972. However, we have not as yet had the time to make an extensive use of the wealth of information that the air photos represent.

Field work. During the snow build-up period we have twice visited the Prudhoe Bay area on the Arctic Slope for snow measurements and to attend

our meteorological equipment.

2. Applicability of ERTS-1 data to project objectives.

The delineation of the snow cover in the high mountain areas, in the Brooks Range and on the Arctic Slope can generally be made directly from any of the four NASA provided MSS prints. However, depending on the atmospheric turbidity conditions and the spectral signatures of snow and the surrounding terrain, an optimal contrast is generally attained on one of the four bands. To illustrate some of the possibilities to describe snow and ice, and also some of the problems pertaining to our ERTS analysis we have selected the following scenes:

1050 - 20560 (September 11). On this scene one may identify distinct snow lines on the major glaciers in the Mt. McKinley massif. Generally the snow line appears most distinctly in band 7, i.e. in the infrared. We have displayed some glacier scenes on the CAV in order to obtain additional information in characteristics of the glacier surface, so far without success.

1051 - 21002 (September 12). On this scene of Brooks Range there are 15-20, possibly more, aufeis deposits identifiable. The biggest of these fields are of a order of size given by a width of 1 mile and a length of 2 miles. Many of the deposits do not melt completely throughout the summer. It should be especially interesting to monitor the variations of these deposits from year to year by the ERTS data.

1073 - 21225 (October 4). This scene shows the accumulation of snow on the Arctic Slope. Lakes and rivers in various stages of freeze-up stand out clearly and open water reaches can be identified. On the Arctic Slope the surface is generally smooth without major topographic features. However, because of intense and frequent snow drifting on the tundra the

snow accumulation pattern is strongly influenced by even minor topographic features like river banks, gravel mounds, sand dunes and pingos. We expect that some of these drift patterns might be recognized on ERTS scenes during the break-up period.

1081 - 20281 (October 12). On this scene of two high mountain areas, Wrangell and Chugach Mountains, the snow line generally is quite distinct and the areal extent of the snow cover can be determined e.g. by planimeter. The identification of the snow line in the high mountains becomes increasingly difficult as the solar elevation above horizon decreases below 10-15°. Marked shadows from mountain tops can be expected to cause identification problems especially if computerized calculations of snow areas are attempted.

1103 - 20502 (November 3). This scene of the Tanana Valley may be taken to represent the effect of snow on the albedo of surfaces with various type and amount of vegetation. With dense vegetation the surface albedo is ordinarily not affected by a snow fall to any great extent. Using this scene as the single source of information it is not possible to state the extent of the snow covers on the ground. We are not trying to find analytical means, including displays of repetitive satellite data over one and the same test area on the CAV and also comparisons between air photos and satellite photos, that might be used to identify snow in various types of terrain.

3. Results

The main results of our ERTS analysis made so far are related to the possibilities to add new information and thus enhance the present system of gathering snow data in Alaska. The best way to illustrate this is perhaps by reference to series of images showing regional variations of snow and ice in our test area at selected times during the snow build-up

period. We have selected the following scenes to form mosaics made by contrast enhanced and enlarged photos. The mosaics are not yet ready.

Mosaic No. 1: 1050 - 20541, 1051 - 20595, 1051 - 21002 (September 11 and 12). These scenes show the deposition of snow after an early snow fall over the Brooks Range and the Arctic Slope. There is new snow on the hill tops in the Brooks Range but more snow on the north than the south foothills. Also, the northern foothills are significantly more affected by wind-action. South of the Brooks Range the snow lies in a relatively undisturbed state on higher ground. In sharp contrast to this, the snow on the north slope of the Brooks Range, is drawn out in long wind-swept patterns. Winds channeled by topography redistribute the snow and actually removes it from selected regions. It may be noted that neither of the two weather stations on the arctic coast (Barrow and Barter Island) or in the Brooks Range (Chandalar Lake) report snow at this time. No formation of lake ice can yet be observed.

Mosaic No. 2: 1063 - 20273, 1063 - 20280, 1063 - 20282 (September 24). This mosaic shows the snow distribution across the Alaska Range, together with the Wrangell and Chugach Mountains, after the first more significant snow fall, which took place around September 14-17 (Section II B.1). The deposition of new snow has mainly affected the Alaska Range and the Wrangell Mountains where many glaciers have become snow covered and the elevation of the snow line along the mountain sides fluctuates around 3000 feet. Starting from the southern outliers of the Wrangell Mountains and southwards across the Chugach Mountains there is a marked decrease in the accumulation of new snow. This may be deduced from the fact that the ablation areas of the glaciers are still quite distinct and that many high mountains tops are not affected by snow. It may be noted that none of

the climatological stations in this whole region report snow on ground at this time. No formation of lake ice is observed on these scenes.

Mosaic No. 3: 1072 - 21173, 1072 - 21180, 1073 - 21223, 1073 - 21225, 1073 - 21232 (October 3 and 4). This mosaic across Arctic Slope, Endicott Mountains in the Brooks Range, and Ray Mountains shows a fairly advanced snow cover for the season after the wide-spread snow falls over Alaska at the end of September but before the warm weather period in the middle of October. On the Arctic Slope there is a continuous snow cover except for major rivers which stand out clearly against the snow cover as do lakes in the final stages of freeze-up. Open water reaches can be observed on the major rivers and also on some of the lakes. Going across the divide of the Brooks Range southwards there is a marked decrease of the surface albedo in the valleys. Preliminary investigations of surface characteristics on both sides of the divide, using NASA air photos from flight lines 12 and 13 show that the decrease of the albedo southwards is due to a combination of decreased snow accumulation and increased vegetation density. The Brooks Range as a climatic divide can also be noticed in the freeze-up of the lakes since in the southern part of the Brooks Range the big lakes have not yet started to freeze over. On the other hand, in the Koyukuk River basin further south the freeze-up pattern is more variable with some of the big lakes frozen over.

The mountain areas south of the Brooks Range are generally snow covered while it is considerably more difficult to make general statements about the snow conditions in the low lands because of vegetation of varying type and density. Most weather stations in the Interior report snow cover at this time, however, in some cases the snow is less than 5 cm deep.

As mentioned in Section II B. 1, most of the snow at lower levels disappeared during a warm weather period in the middle of October. Also on the Arctic Slope a noticeable degradation of the snow cover took place as indicated e.g. on scene 1090 - 21180.

Mosaic No. 4: 1081 - 20275, 1081 - 20281, 1081 - 20284, (October 12). This mosaic shows the same area as mosaic No. 2. The snow cover has expanded considerably since September 24 especially in the Chugach Mountains where the snow line now may be found at elevations of about 1500 feet on the southernmost slopes facing the Gulf of Alaska. In the Alaska Range the snow cover has expanded in the south-facing valleys while there is little change in the north-facing valleys. The majority of the lakes in the Alaska Range area are frozen over, notable exceptions among the big lakes are Copper and Tanada Lakes at 2905 and 2885 feet elevation above m.s.l. respectively Jatahumud Lake at 2171 feet is partly ice covered and Tetlin Lake at 1653 feet is frozen over.

The snow accumulation pattern before September 24 was thus quite dissimilar to the pattern during the period September 24 to October 12. Most of the snow before September 24 was probably associated with a westerly to northwesterly flow at the 500 mb level over this part of Alaska (Section II B. 1), while the corresponding flow was predominantly southwesterly to westsouthwesterly during the snow fall period September 26-30. It may also be noted that a southwesterly to westerly flow prevailed from October 1 to 12.

Mosaic No. 5: 1103 - 20493, 1103 - 20495, 1103 - 21502, 1103 - 20504, 1103 - 20511, 1103 - 20513, 1103 - 20520 (November 3). These scenes represent a transect across the whole state of Alaska from the Brooks Range in the north to the Kenai Peninsula in the south. However, they were collected

shortly before the satellite was turned off because of poor light conditions caused by low solar elevations. We have not been able to make a detailed analysis as yet of this transect using the NASA provided prints. However, we have had the opportunity to see some of these scenes on enlarged and contrast enhanced prints and we feel confident that this mosaic will be a valuable compliment to the description of the build up of snow and ice covers in the fall of 1972.

III New Technology

None

IV Plans for the next reporting period.

Next bi-monthly period (February and March): We will finish the analysis of the snow and ice build-up including variations of snow lines with elevation and the areal extent of snow in a few selected basins. We also intend to finish the analysis of the relationships between snow and ice build-up and meteorological parameters.

Six month period:

The main emphasis in our analysis will be the break-up conditions. The analysis will mainly follow the lines outlined above as to the build-up conditions and also outlined in our revised data handling plans. We now look forward to receive ERTS data for the snow break-up period after the break in the data flow between November 5, 1972 and February 15, 1973.

V Conclusions

In summary, the main result from our analysis of the snow build-up period is that the ERTS data can provide useful information on snow accumulation patterns in the high mountain areas of southern Alaska, in the Interior mountains and in the Brooks Range, and on the Arctic Slope

where the vegetation is mostly of tundra type. The usefulness of the ERTS for description of snow covers on flats in the Interior or in valleys with dense vegetation is not yet clear from our analysis. The ERTS data also provides information on the freeze-up of lakes and rivers, which should be especially useful for discussions of the areal representativeness of point measurements.

During the period of freeze-up and initial snow formation the pattern of wind drifted snow provides a clear picture of low-level wind patterns over wide spread, complex topographic features. The possibility of seeing such vast expanses of remote country, spanning two major climatic boundaries is unique to these ERTS images. In addition to the snow distribution patterns we have also observed considerable variability in the date of freeze-up of lakes and rivers. The causes for the different freezing dates can be sought far more easily with ERTS imagery extending over several autumnal seasons. Our present hydrological needs find less immediate practical application for these data from the freeze-up and snow build up period than for the break-up period. On the other hand, determinations of the areal extent of the snow and of the elevation of the snowline in the mountains during the break-up period, have a direct practical value for hydrological forecasting, since a major part of stream flow in Alaskan rivers originates from snow melt. Our intention is to devote most of our efforts to study the break-up conditions. However, it should be pointed out that the build-up of the seasonal snow and ice covers are sensitive indicators of climatic fluctuations. The ERTS data offers a possibility to record variations of the snow and ice build-up from year to year in a practical and informative way and should be

especially useful for studies of climatological trends. This is particularly true in Alaska where the density of the station network is too low to permit interpolations between the stations.

VI Recommendations

None

VII Publications

None

VIII References

None

APPENDICES

Appendix A - Change in standing order forms

None

Appendix B - ERTS Data Request Forms

Request submitted on August 22, 1972

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

DATE February 20, 1973PRINCIPAL INVESTIGATOR Gunter E. WellerGSFC UN 681ORGANIZATION Geophysical Institute, University of Alaska

NDPF USE ONLY

D _____

N _____

ID _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Snow	Ice	Glaciers	
1050 - 20560 M	✓	✓	✓	
1050 - 20541 M	✓	✓	✓	
1051 - 20595 M	✓	✓	✓	
1051 - 21002 M	✓	✓		
1072 - 21173 M	✓	✓		
1072 - 21180 M	✓	✓		
1073 - 21223 M	✓	✓		
1073 - 21225 M	✓	✓		
1073 - 21232 M	✓	✓		
1081 - 20275 M	✓	✓	✓	
1081 - 20281 M	✓	✓	✓	
1081 - 20284 M	✓	✓	✓	
1103 - 20493 M	✓	✓		
1103 - 20495 M	✓	✓		
1103 - 21502 M	✓	✓		
1103 - 20504 M	✓	✓		
1103 - 20511 M	✓	✓	✓	
1103 - 20513 M	✓	✓	✓	
1103 - 20520 M	✓	✓	✓	
1105 - 21015 M	✓	✓	✓	

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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Appendix D - Significant Results

Major aufeis deposits can be identified after the disappearance of the snow cover. As an example may be taken scene 1051 - 21002, on which 15-20 major aufeis fields may be identified. Freeze-up patterns on major lakes and rivers may be observed on ERTS imagery. On an enlarged and selectively contrast enhanced scene (1103 - 21015) we have been able to see alternately open and frozen water reaches on the Yukon and Tanana Rivers.

The build-up of the seasonal snow and ice covers across the major mountain ranges in Alaska has been described by five series of scenes, each series containing three scenes or more obtained at selected times during the period September 11 - November 3. The snow build-up has been related to synoptic weather patterns and orographic affects.